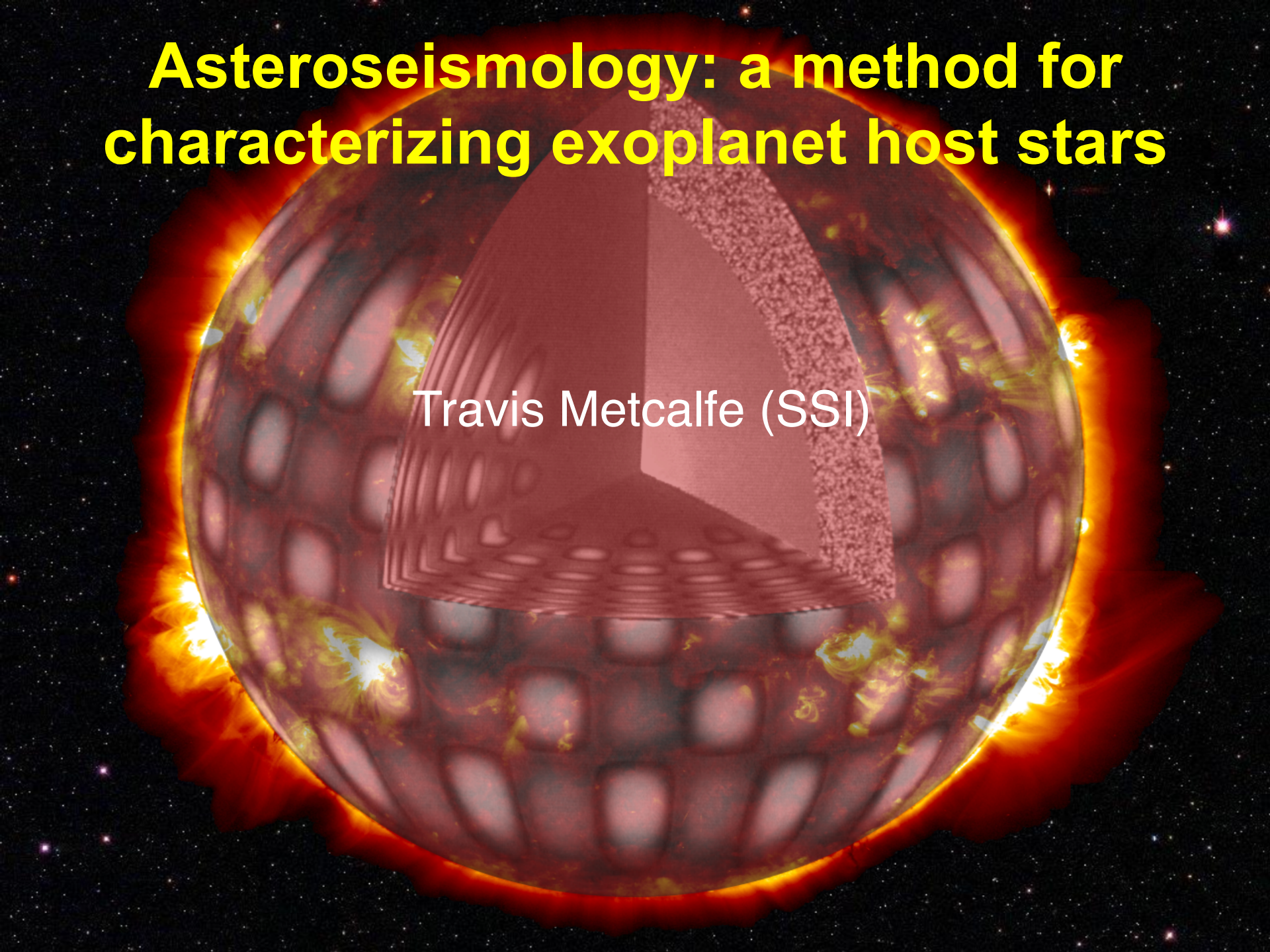
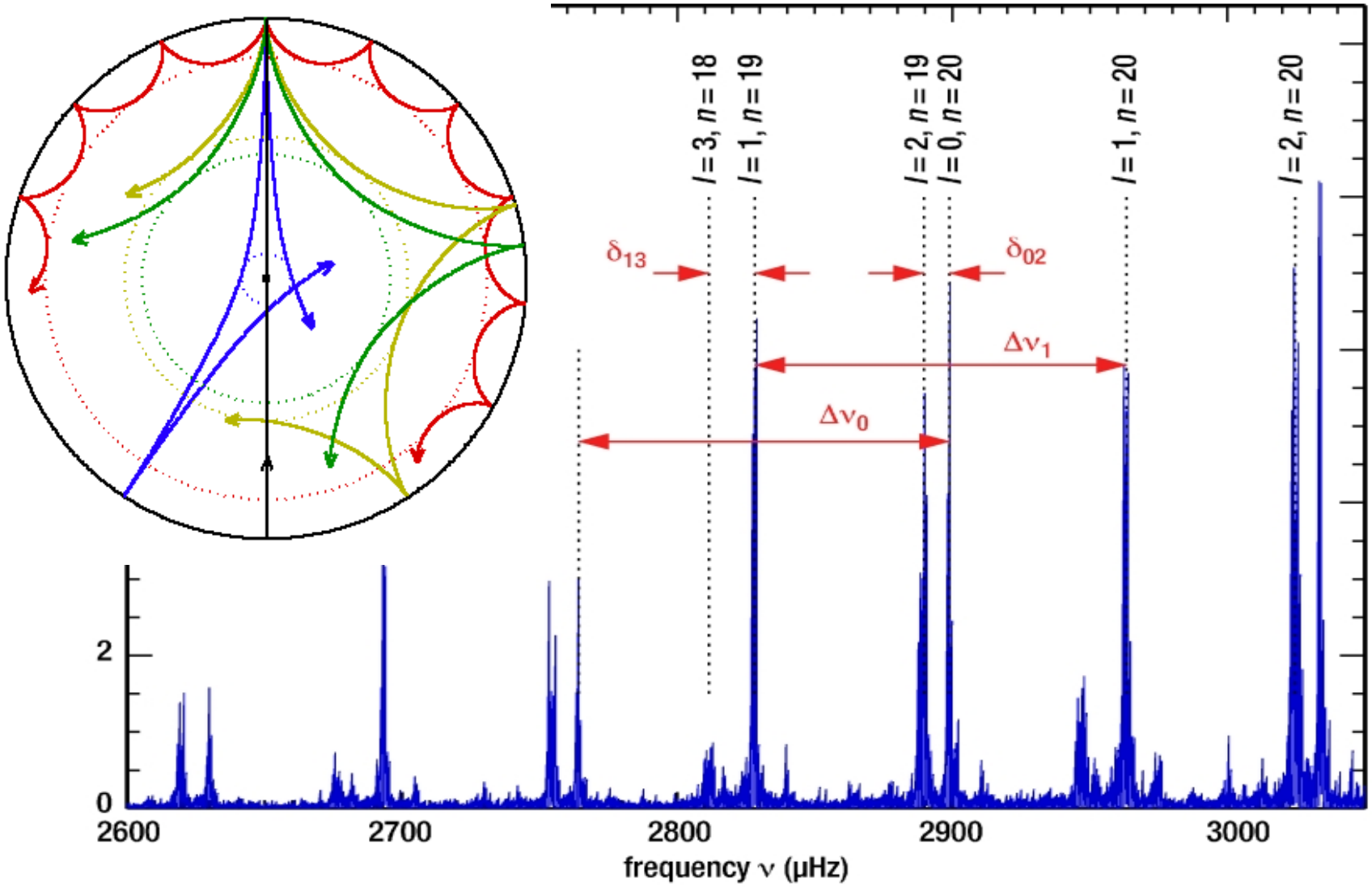
Asteroseismology: a method for characterizing exoplanet host stars



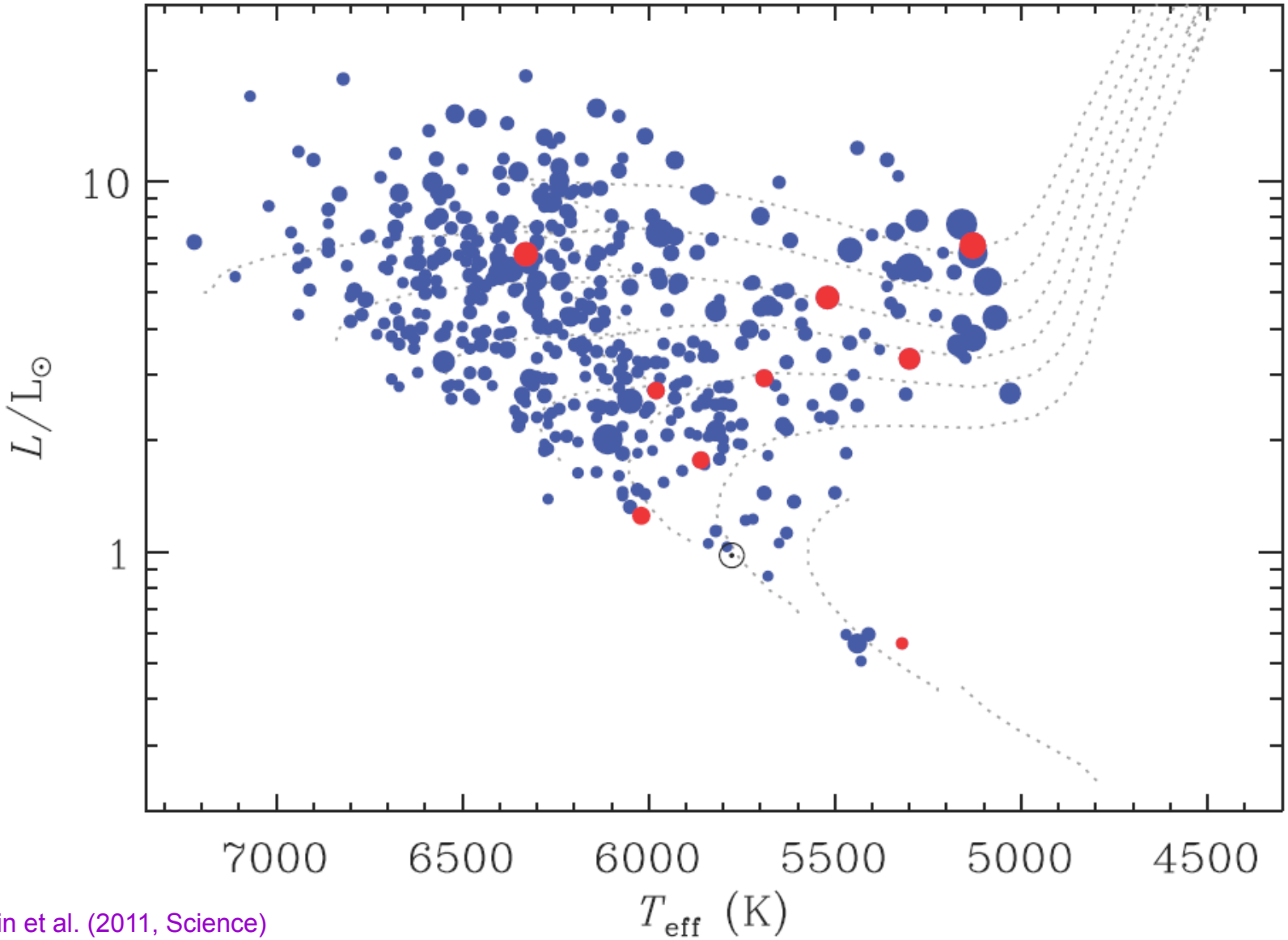
Travis Metcalfe (SSI)

Global oscillation properties



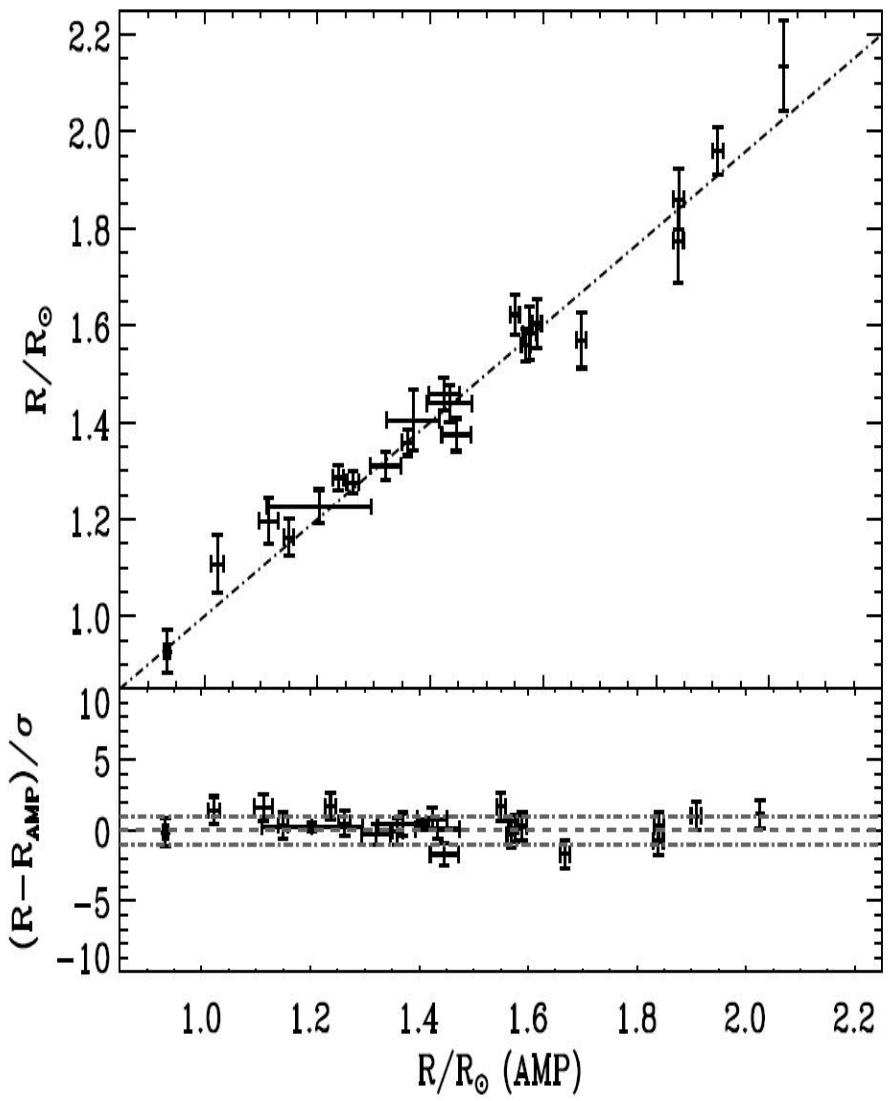
Elsworth & Thompson (2004)

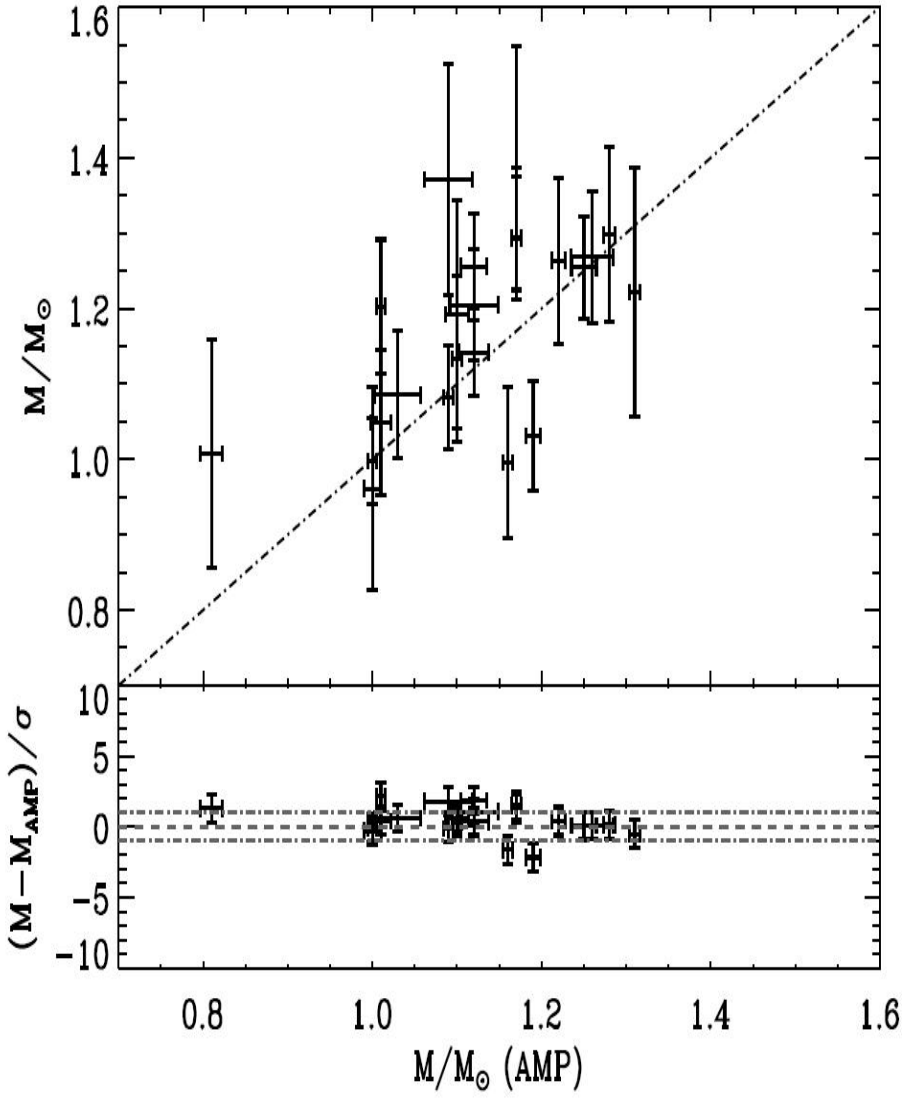
Kepler asteroseismic survey



Chaplin et al. (2011, Science)

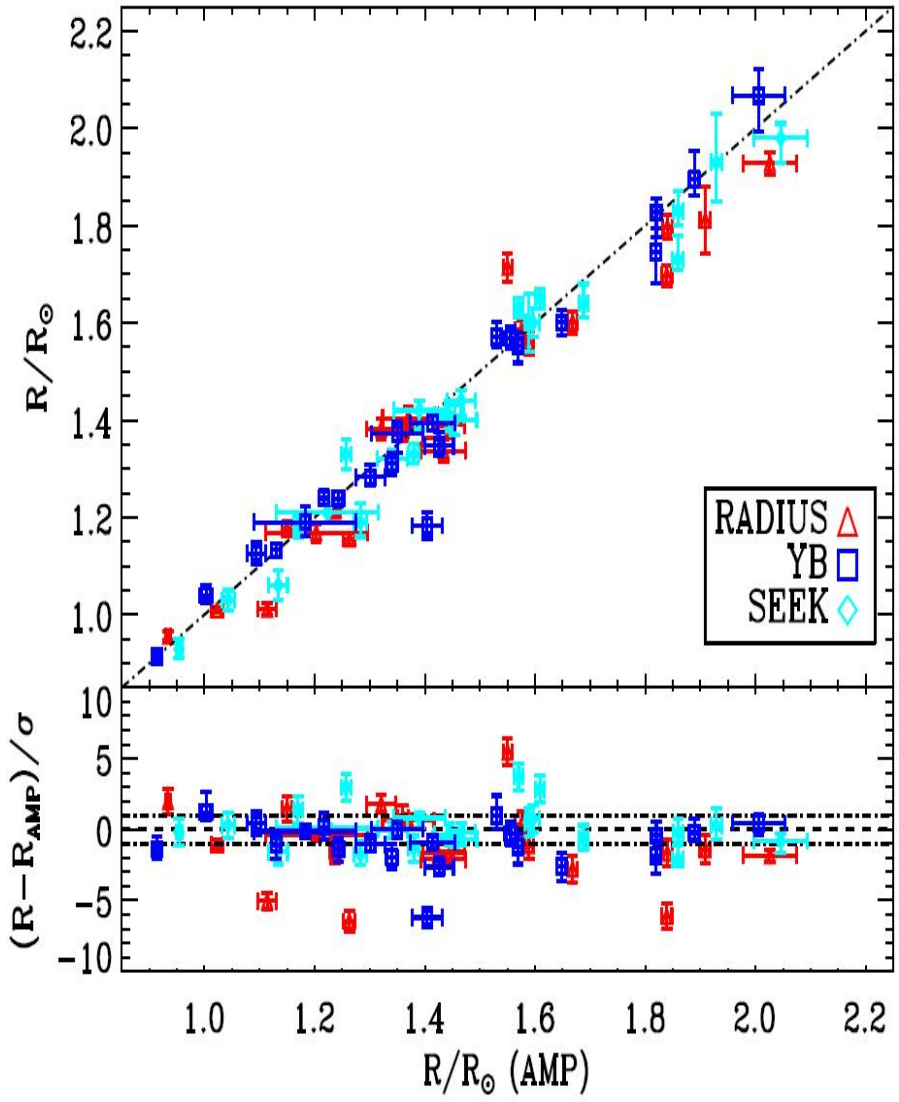
Scaling relations

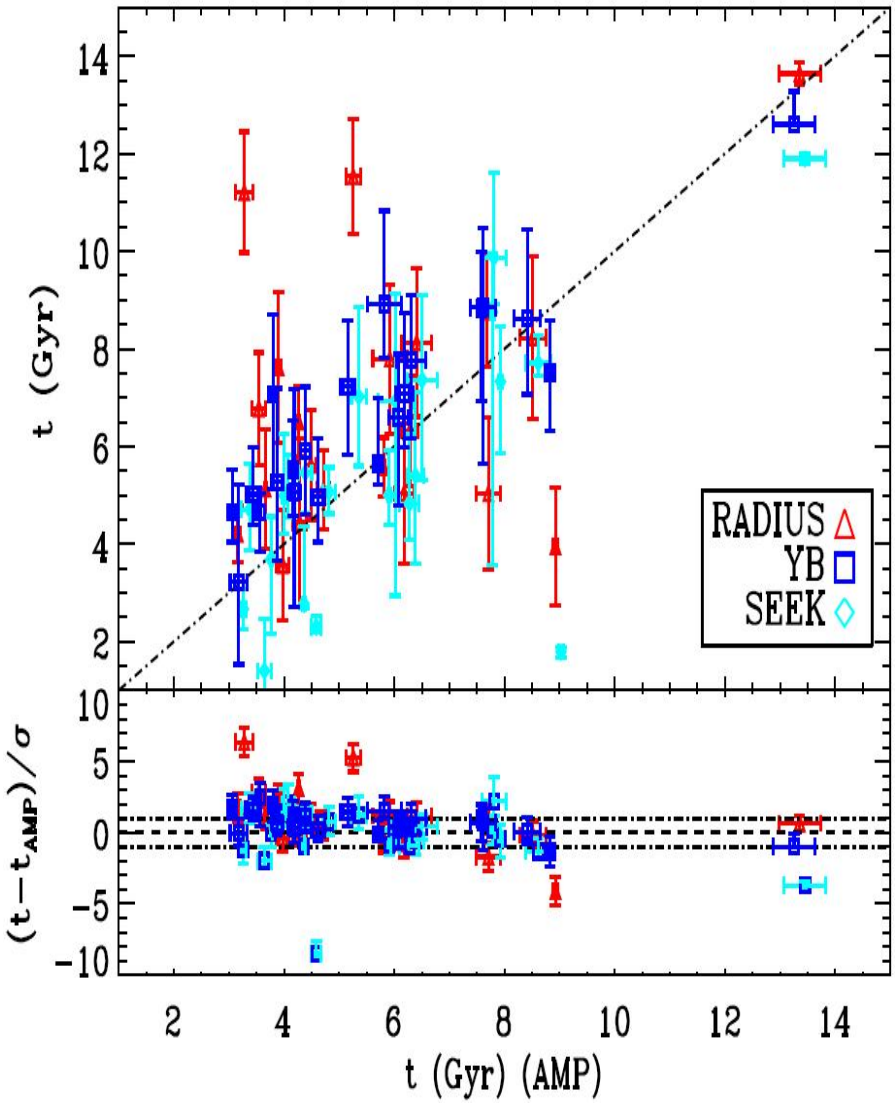




Mathur et al. (2012)

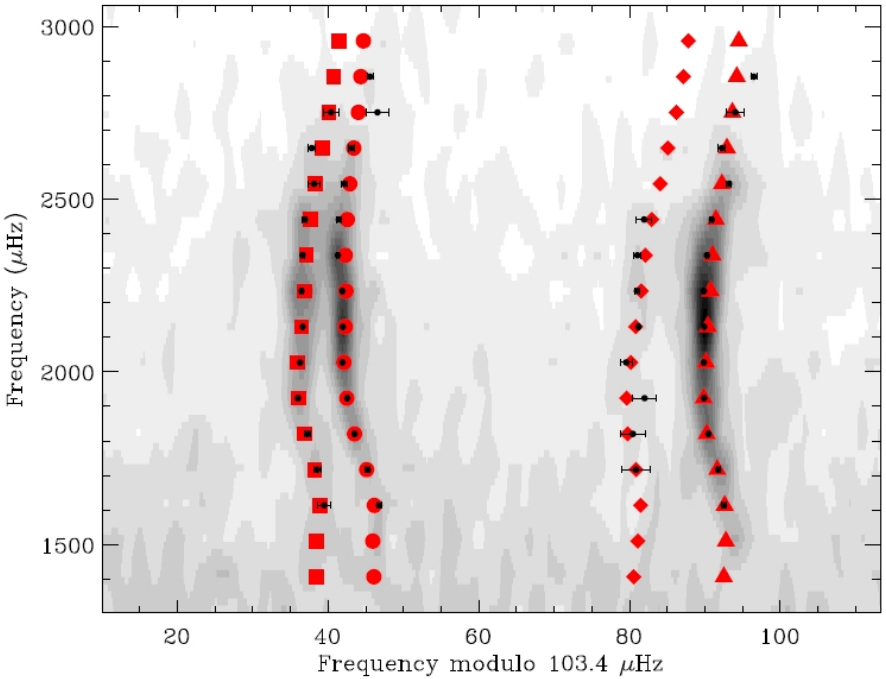
Model grid-based methods

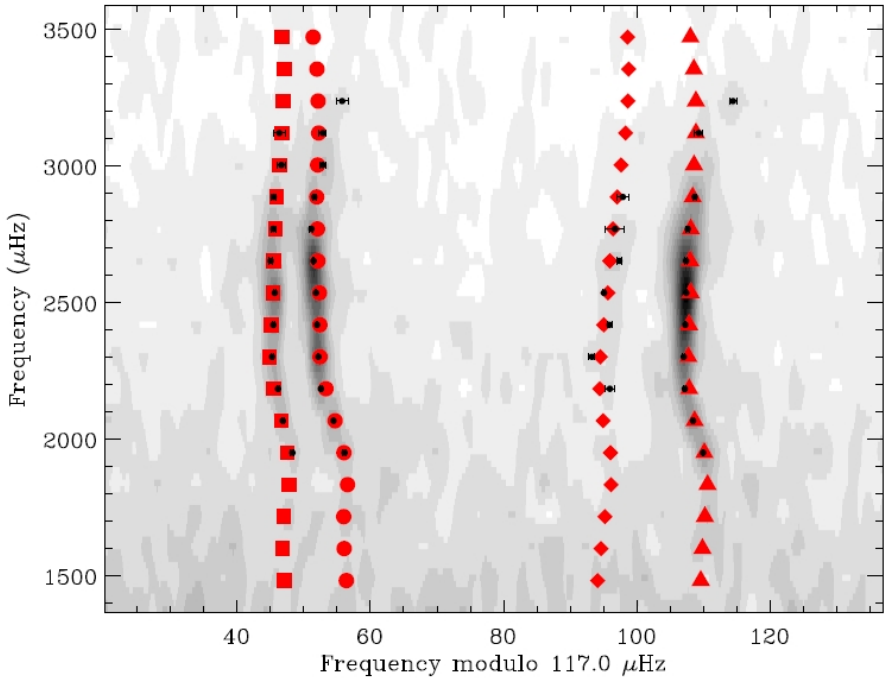




Mathur et al. (2012)

Fitting the frequencies

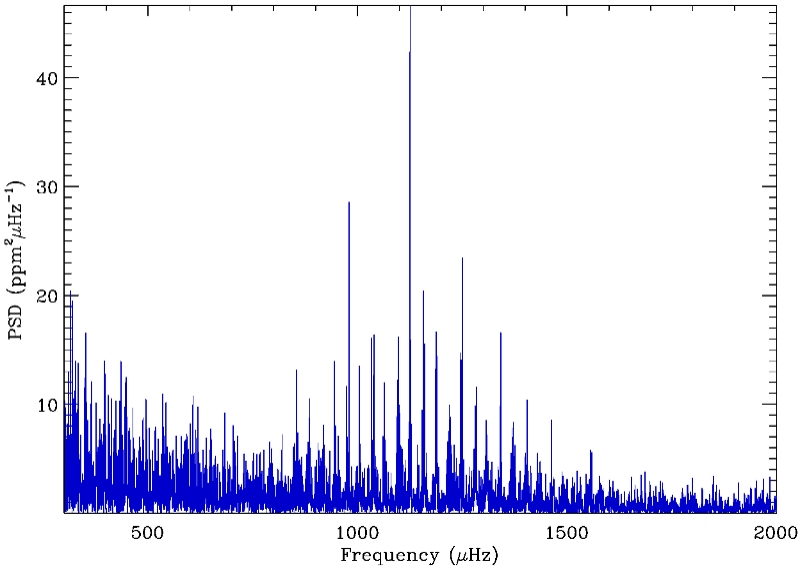


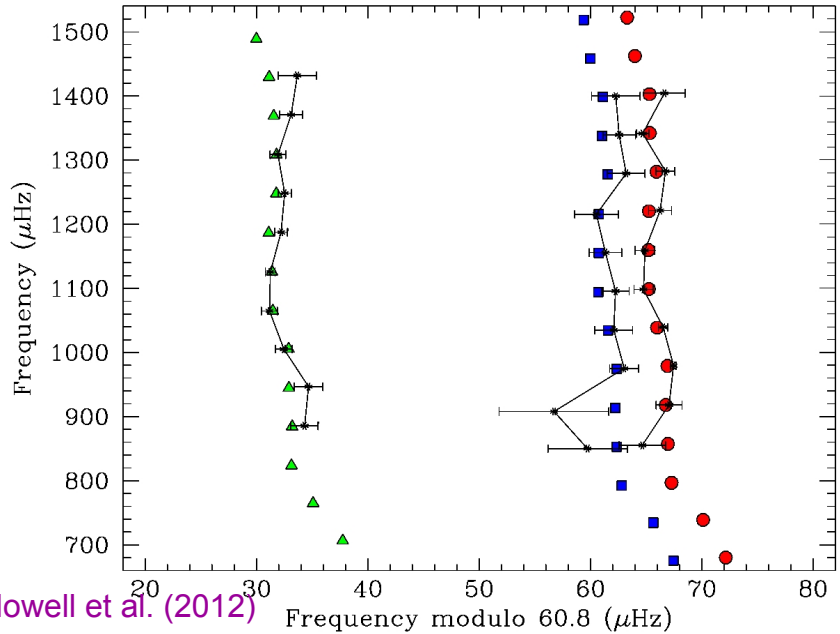


	16 Cyg A							16 Cyg B						
	$R/R_\odot$	$M/M_\odot$	t(Gyr)	Z_i	Y_i	α	χ^2	$R/R_\odot$	$M/M_\odot$	t(Gyr)	Z_i	Y_i	α	χ^2
AMP.....	1.236	1.10	6.5	0.022	0.25	2.06	5.47	1.123	1.06	5.8	0.020	0.25	2.05	9.80
σ_{stat}	0.016	0.01	0.2	0.002	0.01	0.03	...	0.020	0.01	0.1	0.001	0.01	0.03	...
ANKİ.....	1.260	1.14	6.4	0.024	0.26	1.94	21.41	1.138	1.08	6.4	0.022	0.26	1.94	23.29
ASTEC1..	1.237	1.10	7.5	0.023	0.25	2.00	5.70	1.121	1.05	7.3	0.021	0.25	2.00	7.97
ASTEC2..	1.235	1.10	6.8	0.022	0.25	2.00	7.70	1.134	1.09	6.3	0.025	0.25	2.00	8.47
CESAM...	1.253	1.14	7.0	0.027	0.24[a]	0.72[b]	3.53	1.136	1.09	6.9	0.025	0.24[a]	0.73[b]	4.78
Geneva....	1.236	1.10	6.7[c]	0.024[c]	0.26[c]	1.80[c]	10.82	1.122	1.06	6.7[c]	0.024[c]	0.26[c]	1.80[c]	10.98
YREC	1.244	1.11	6.9	0.026	0.26	2.08	5.68	1.121	1.05	6.9[d]	0.022	0.26	1.84	3.17
adopted	**1.243**	**1.11**	**6.9**	**0.024**	**0.25**	**2.00**	...	**1.127**	**1.07**	**6.7**	**0.023**	**0.25**	**1.92**	...
σ_{sys}	0.008	0.02	0.3	0.002	0.01	0.08	...	0.007	0.02	0.4	0.002	0.01	0.09	...

Metcalfe et al. (2012)

Kepler-21: a love story

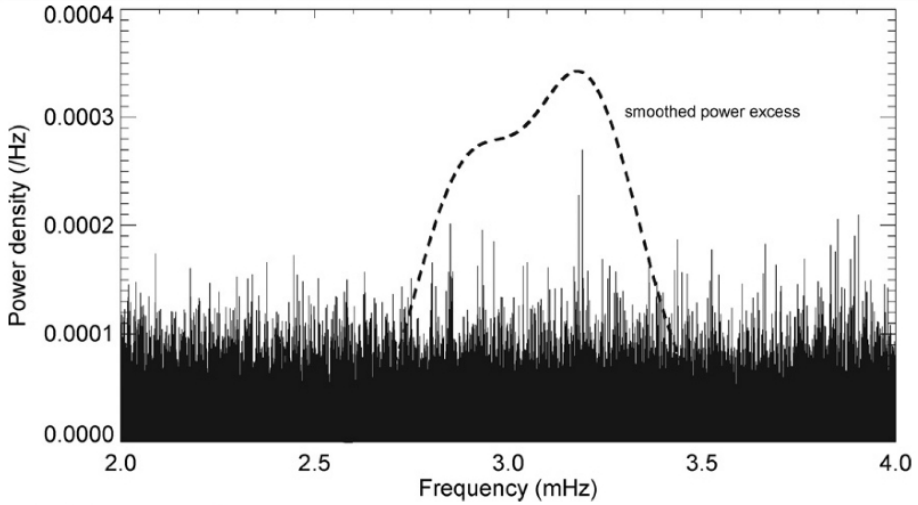


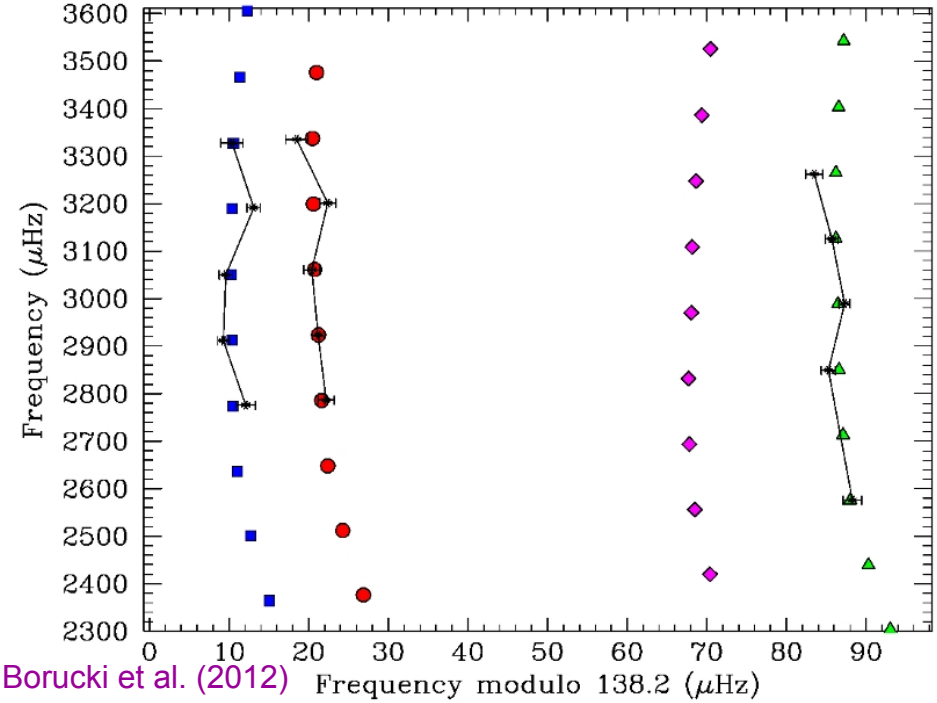


- 1.64±0.04 R_e planet in a 2.8-day orbit around an oscillating F subgiant
- Asteroseismic target prior to exoplanet discovery, expanded collaboration
- radius (1.86±0.04 $R_\odot$), mass (1.34±0.06 $M_\odot$), age (2.84±0.34 Gyr)

Howell et al. (2012)

Kepler-22: habitable super-Earth

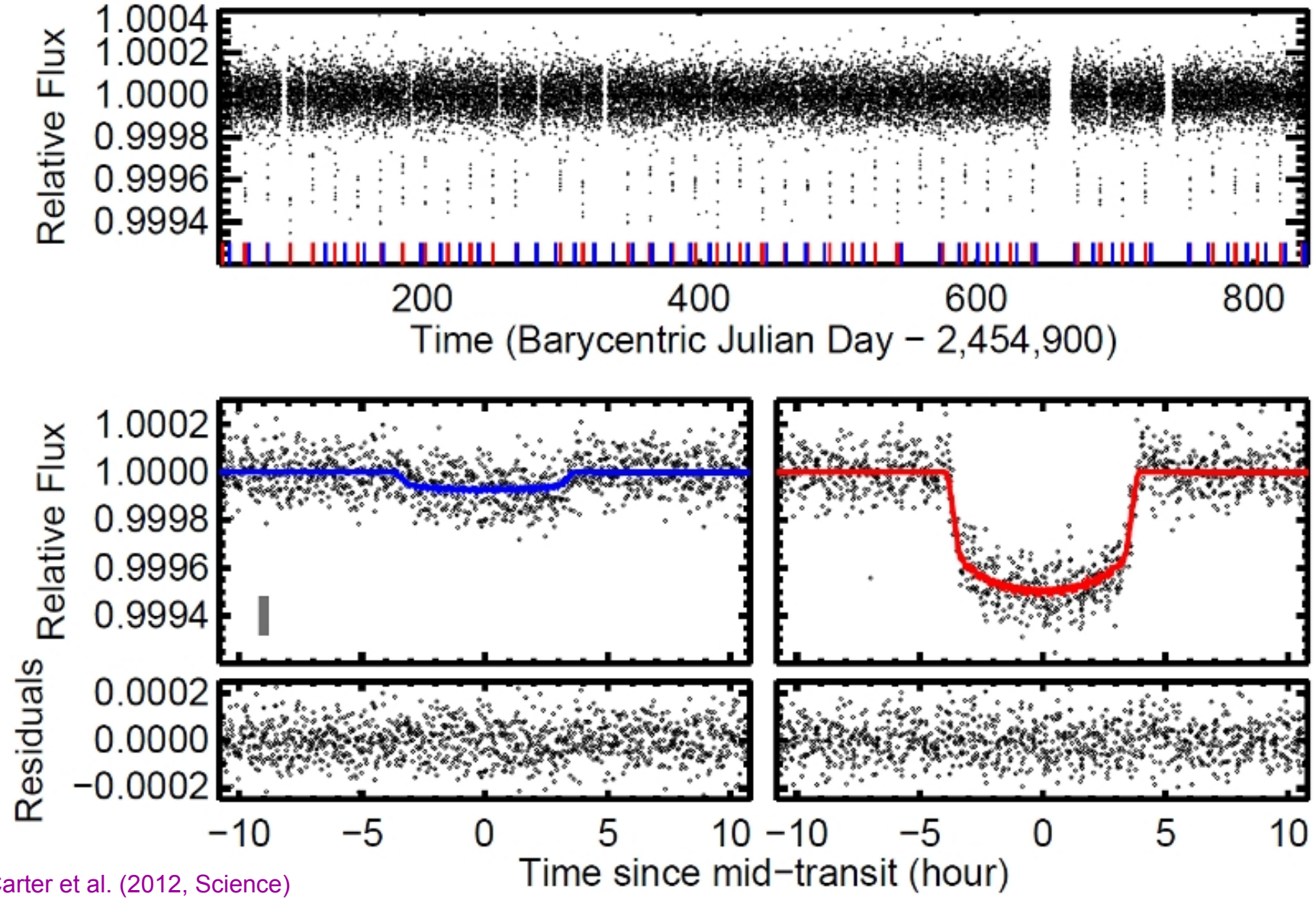




- 2.38±0.13 R_e planet with 290-d orbit in habitable zone of G5 host star
- Spectroscopy and global oscillation properties for grid-based modeling
- radius (0.98±0.02 $R_\odot$), mass (0.97±0.06 $M_\odot$), age (~4 Gyr)

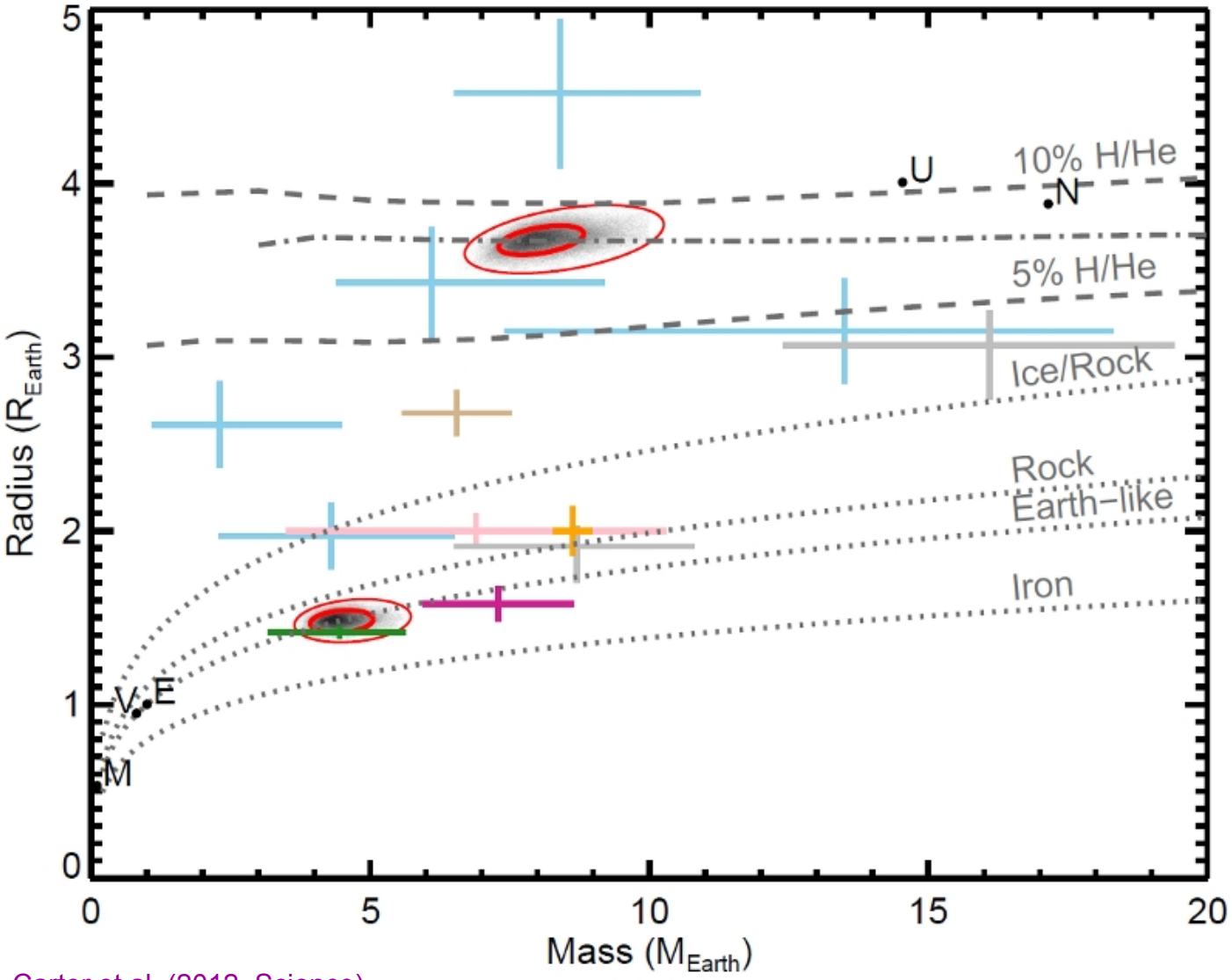
Borucki et al. (2012)

Kepler-36: formation puzzle



Carter et al. (2012, Science)

Kepler-36: formation puzzle



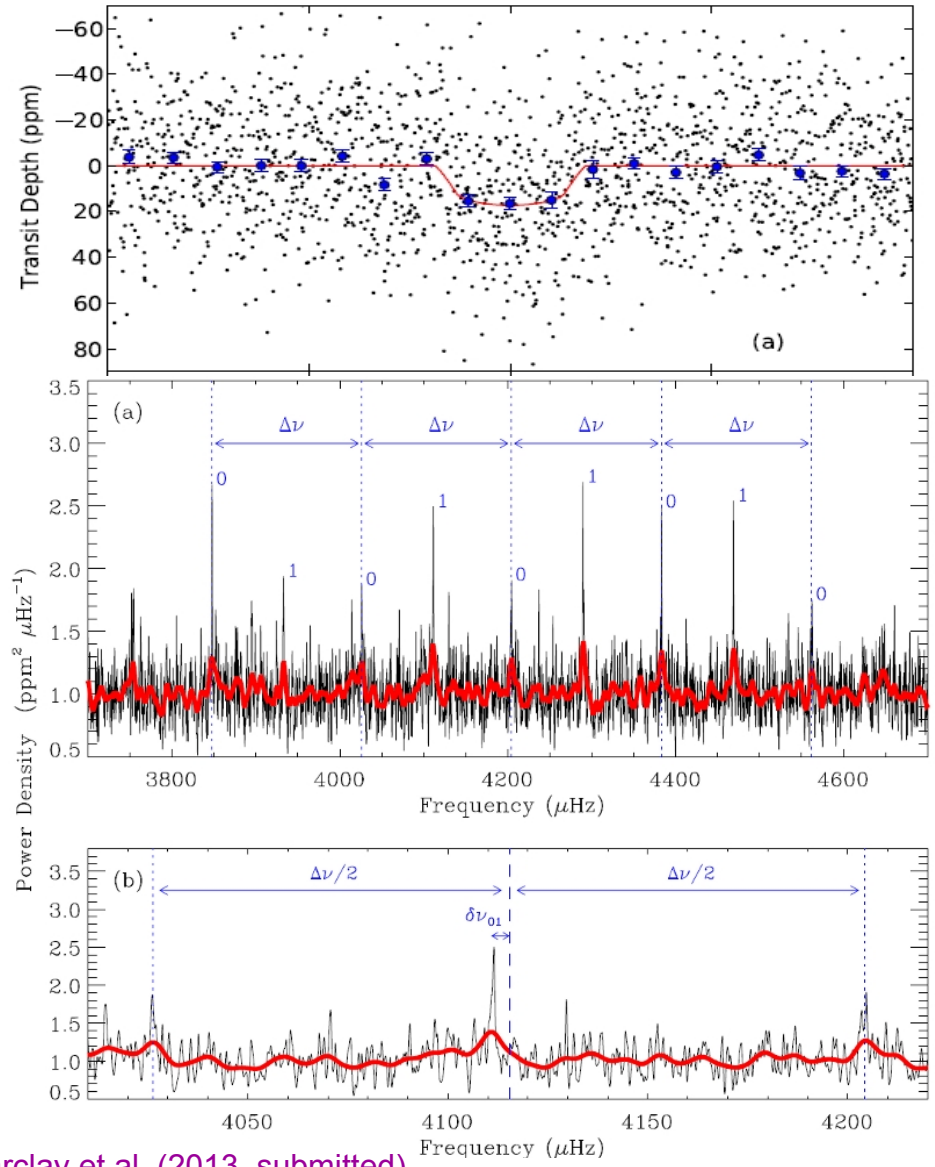
' R_e planets in
16.2-d orbits
ratio)

mology and
ıg variations
t densities

h and Neptune
y ratio) in
g orbits. How?

Carter et al. (2012, Science)

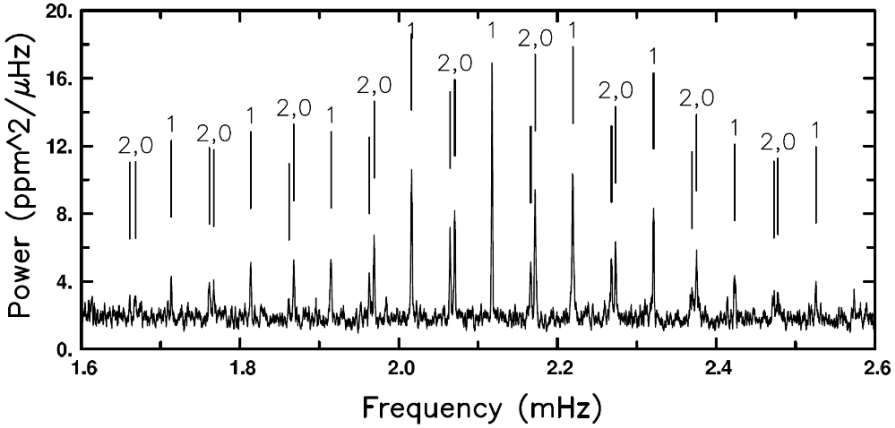
Kepler-37: smallest exoplanet

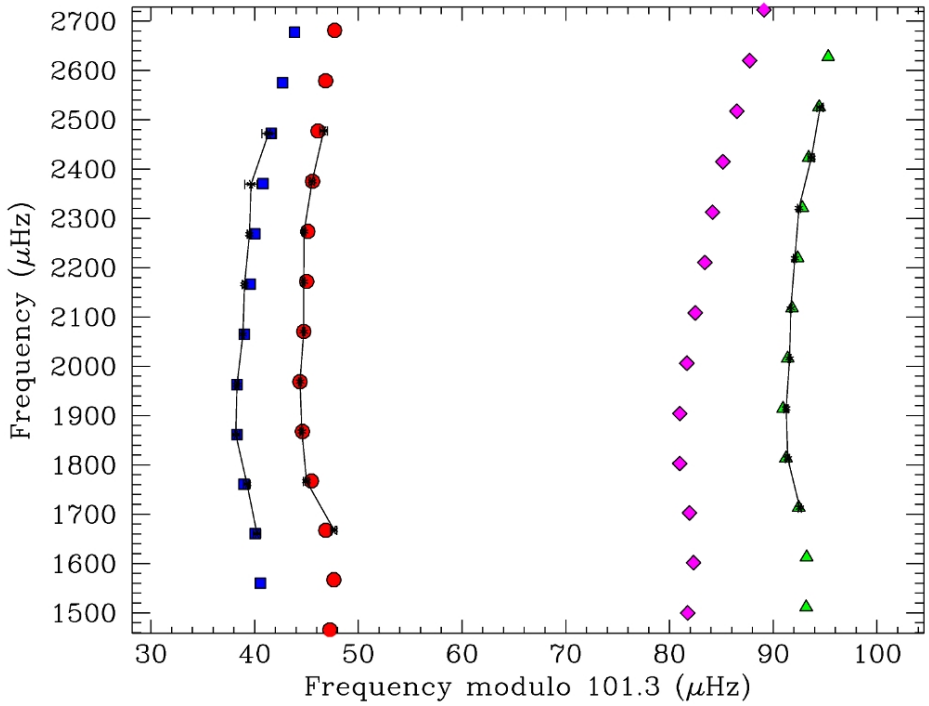


- 0.3 / 0.74 / 2.0 R_e planets in 13 / 21 / 39 day orbits (no TTVs yet detected)
- radius (0.77±0.02 $R_\odot$), mass (0.80±0.04 $M_\odot$), age (~6 Gyr)
- Innermost planet is smaller than Mercury (similar to size of Moon)

Barclay et al. (2013, submitted)

Kepler-68: intermediate density

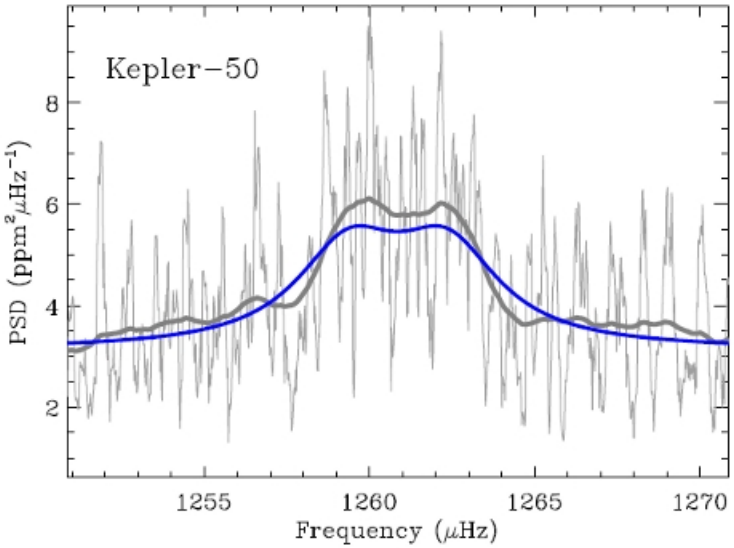


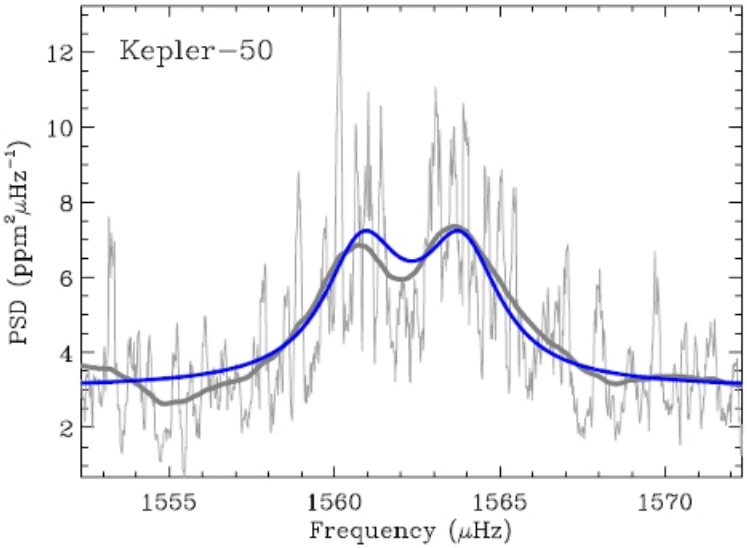


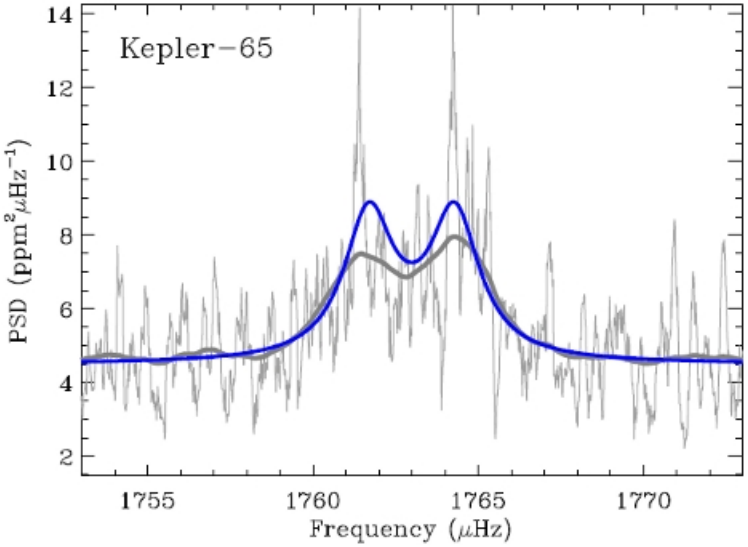
- 2.31 / 0.95 R_e planets in 5.4 / 9.6 day orbits, third planet 0.95 M_J from RVs
- Density of the innermost planet is between that of ice giants and the Earth
- radius (1.24±0.02 $R_\odot$), mass (1.08±0.05 $M_\odot$), age (6.3±1.7 Gyr)

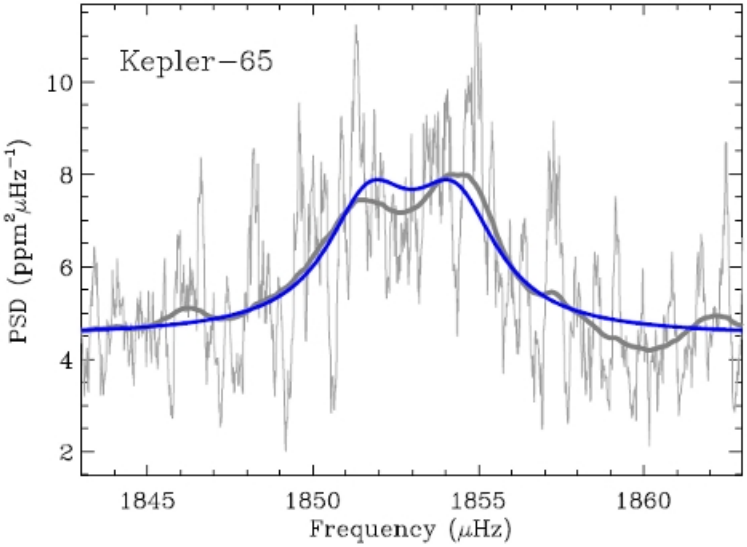
Gilliland et al. (2013, submitted)

Kepler-50 & 65: obliquities



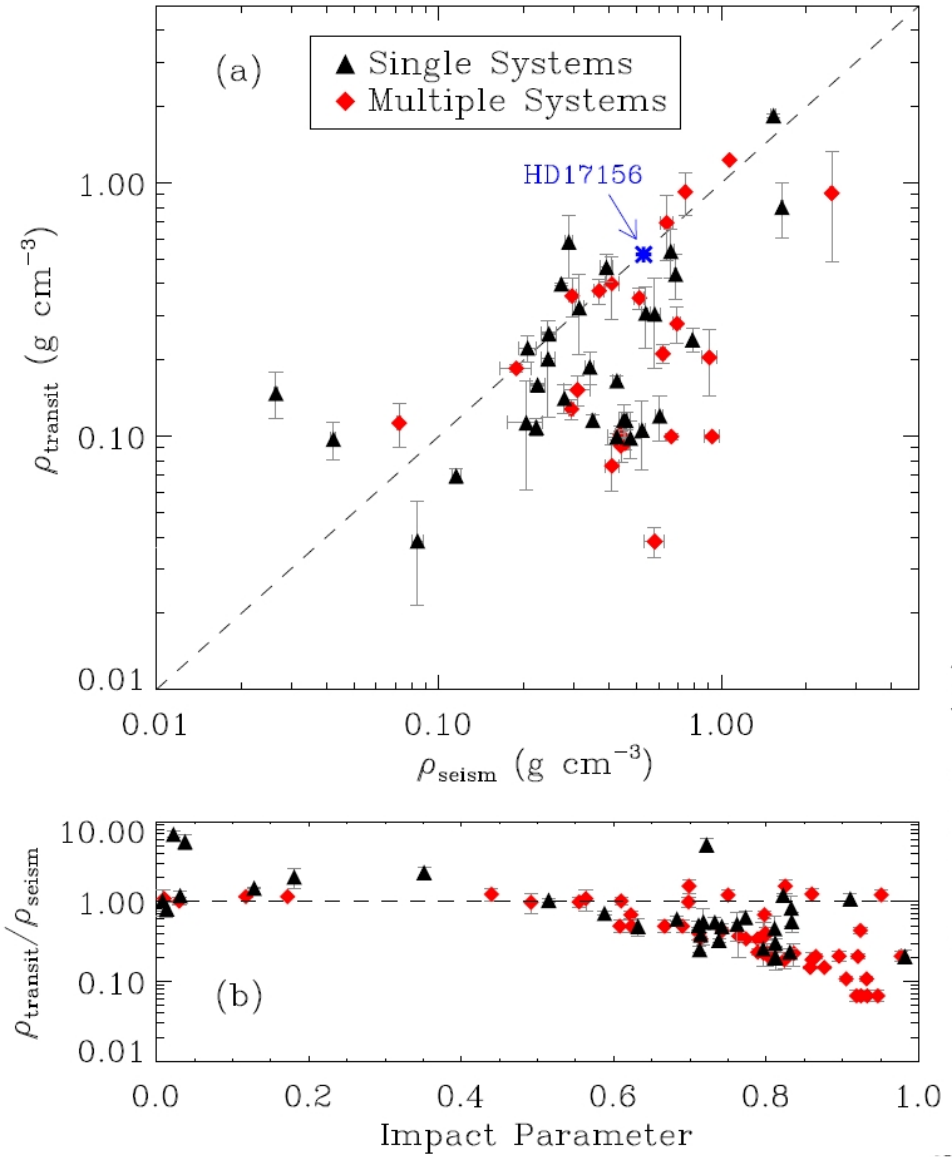


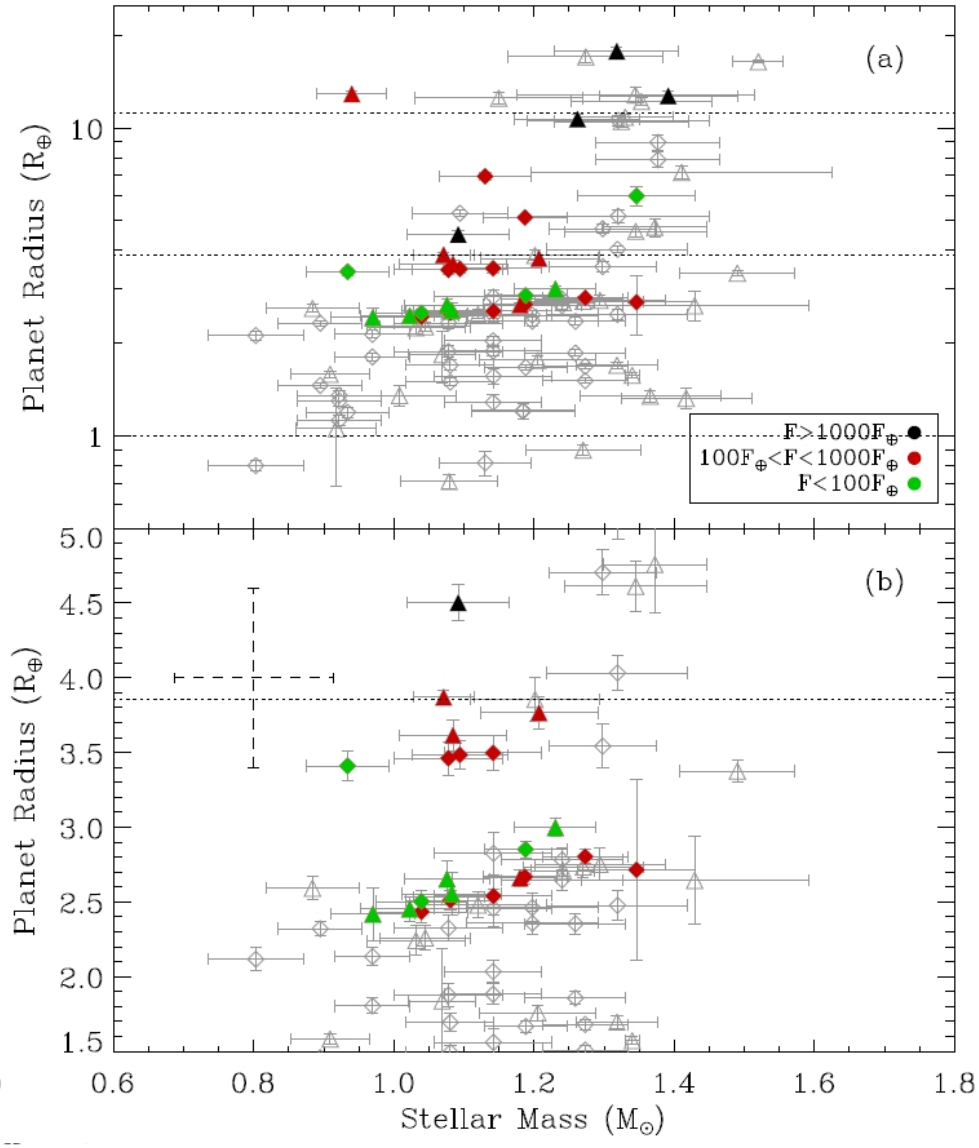




Chaplin et al. (2013, submitted)

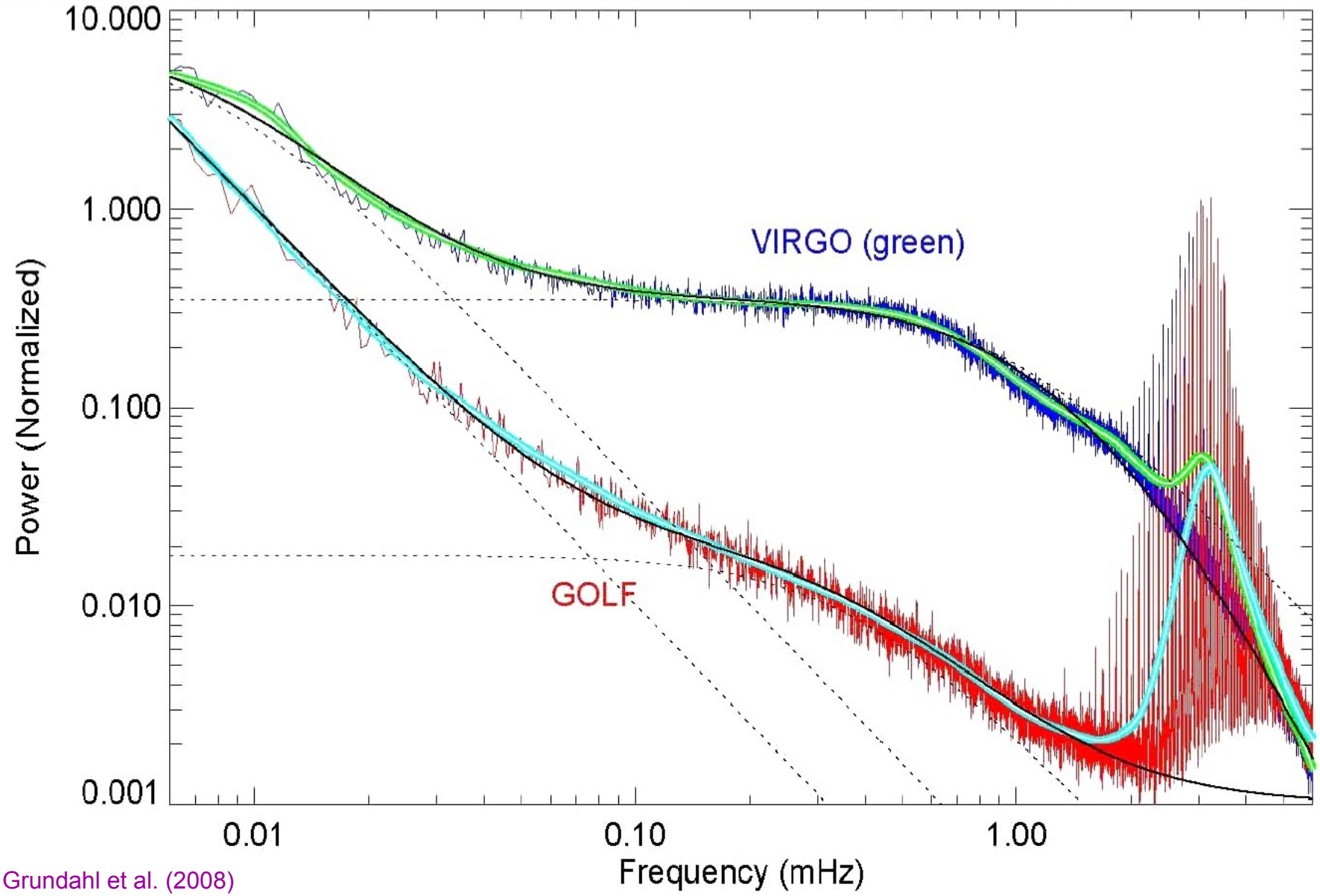
KOI catalog: stellar constraints



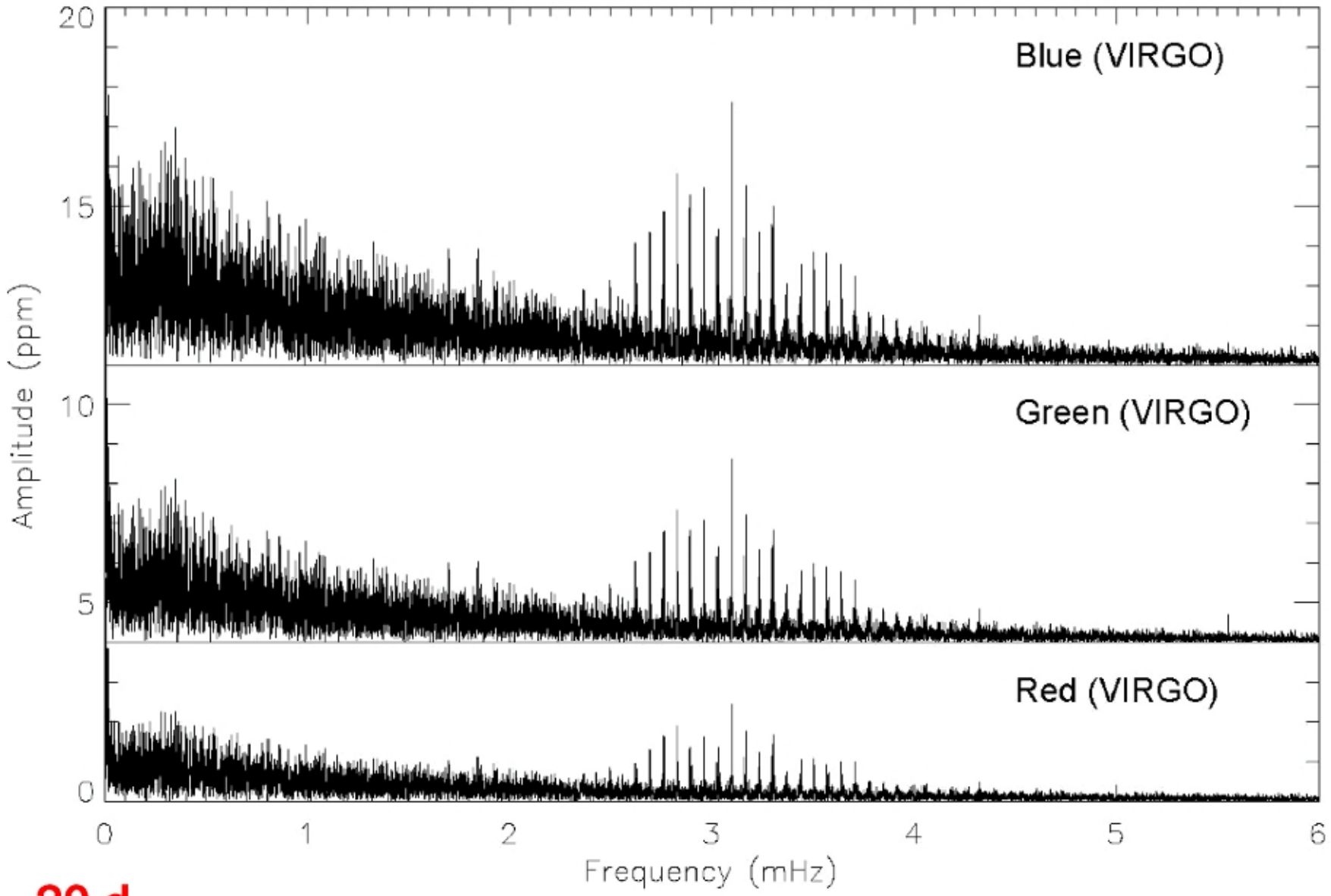


Huber et al. (2013, submitted)

Photometry -vs- Spectroscopy

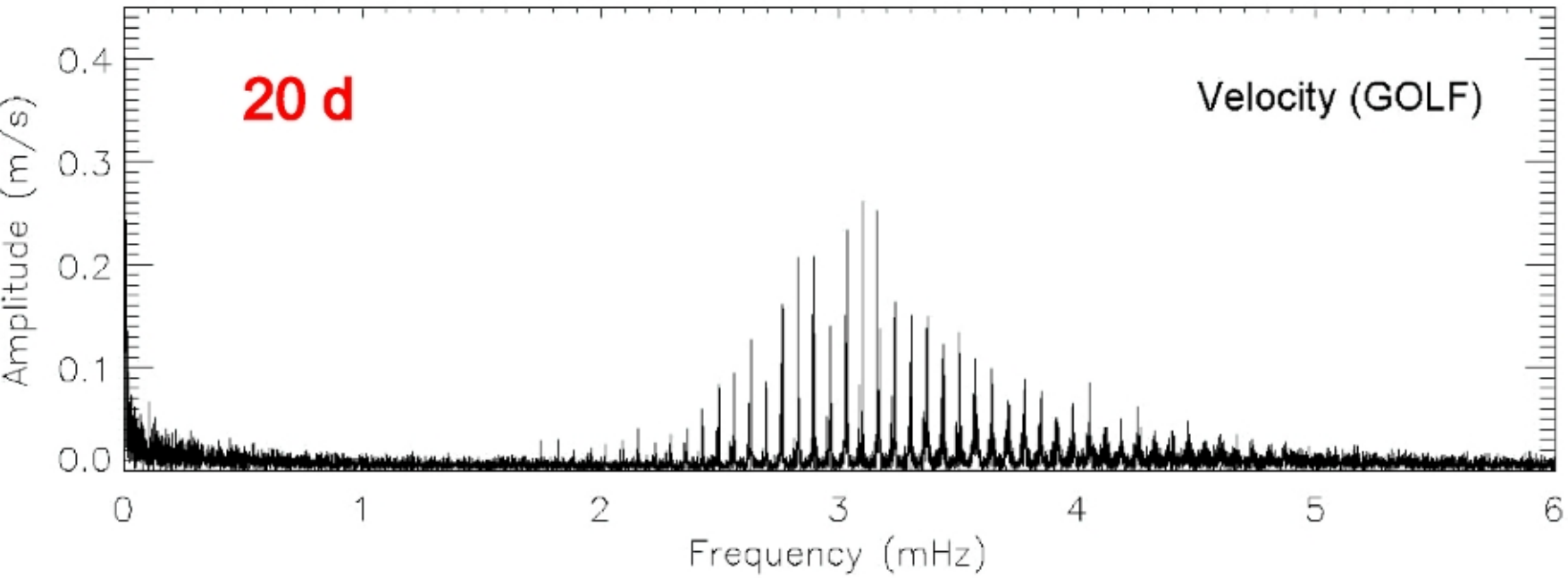


Grundahl et al. (2008)



20 d

H. Kjeldsen



$$\sigma(a) \propto \sigma_{Noise} \cdot T^{-1/2}$$

$$\sigma(f) \propto \sigma_{Noise} \cdot a^{-1} \cdot T^{-1/2}$$

H. Kjeldsen

Recommendations

- Engage asteroseismology community in future exoplanet missions from the start, using implicit European subsidy while supporting US team.
- Avoid Participating Scientist program, allocate additional funding through Guest Observer and Archival Data Analysis opportunities instead.
- Leverage small telescope networks like SONG, support ground-based asteroseismology of the brightest targets from extended RV campaigns.